Evaluation of three indices to assess the esthetic result of single implant-supported crowns

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Thesis submitted in partial fulfillment of the requirement for the degree of
Master of Science

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Abstract

Introduction: Different indices have been proposed in the literature to assess the esthetic outcome of single implant-supported crowns in the anterior maxillary area. The Pink Esthetic Score/White Esthetic Score (PES/WES) rates different soft tissue as well as restorative parameters. The higher the score, the better the esthetic result reaching a maximum of 20 points. Meijer described the Implant Crown Aesthetic Index (ICAI) assigning penalty points to nine selected parameters. A modification of this scoring system was proposed by Vilhjálmsson allowing a total of 18 points for the least esthetic result. The Complex Esthetic Index (CEI) was proposed by Juodzbalys and Wang and consists of the evaluation of five different parameters for three components: soft tissue, radiographic and restorative. The results are expressed as a percentage. To the extent of our knowledge, the specificity and sensitivity of the PES/WES, the modified ICAI and the CEI remain unknown as well as the correlation of each index with the patient's self-reported perception of their treatment.

Materials & Methods: The initial part of the study included the recruitment of 25 subjects. The patients were asked to complete a questionnaire to assess their satisfaction with the implant- supported crown appearance. Two photographs were taken and a radiograph exposed. An independent examiner completed the three indices for the 25 patients. The second part of the study consisted on the scoring of the indices by 5 faculty members from 4 different specialties (orthodontics, periodontics, prosthodontics and oral surgery). The participants evaluated four different cases twice in a two-week period to assess reproducibility. All the data was collected and the statistical analysis completed using SPSS.

Results: The Area Under the Curve (AUC) for the PES/WES was 0.53, for the modified ICAI 0.7 and for the CEI 0.56. The intra-observer agreement was strong for all indices evaluated (p<0.001). PES/WES demonstrated a higher consistency although the difference was not statistically significant. There were no differences between specialists. The scores obtained for

PES/WES, modified ICAI and CEI at TUSDM can be correlated with those published in the literature.

Conclusion: The modified ICAI demonstrated a higher specificity, although the results were not statistically significant. All indices demonstrated a good intra-observer agreement. No differences were observed between the orthodontists, periodontists, prosthodontists and oral surgeons. Both soft tissue and restorative parameters seem to influence the patient's esthetic assessment. Further research is needed to assess if any of the present indices demonstrates a greater correlation with patient's perception as well as intra- and inter-observer agreement to warrant a universal and standardized clinical use.

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Introduction

Implant supported prostheses are currently considered to be the preferred treatment option to restore missing teeth in many indications and have demonstrated high survival and success rates. A recent retrospective analysis revealed a success rate of 97% for implants after 10-years[1]. Albrektsson et al. (1986) published criteria to evaluate the success of dental implants[2]. However, these criteria do not consider the esthetic outcome of implants and are currently believed to be insufficient to evaluate the results of implant therapy.

A rise in the esthetic awareness and resulting standards expected by patients and dental professionals has been evident during the last decades. Consequently, there is still a lack of comparative clinical studies on the long-term esthetic outcome of implant-supported restorations.

In an effort to reach a consensus about the esthetic dimension of implant dentistry, the Third ITI Consensus Conference proposed a series of parameters to evaluate the esthetic outcomes[3]:

- Location of the midfacial mucosal implant margin in relation to the incisal edge or implant shoulder

- Distance between the tip of the papilla and the most apical interproximal contact

- Width of the facial keratinized mucosa

- Assessment of the mucosal conditions (eg, modified Gingival Index, bleeding on probing)

- Subjective measures of esthetic outcomes, such as visual analog scales

Since these criteria were published, and in response to the lack of objective criteria for the evaluation of the esthetic outcome of implants in the esthetic area, a variety of indices have been proposed in the literature. The most commonly used indices are reviewed in the following and considered for further comparison.

1)The Pink Esthetic Score[4]

The first esthetic evaluation of single implant-supported crowns was proposed by Fürhauser in 2005. The Pink Esthetic Score (PES) is based on seven variables that are assessed independently. The variables are: mesial papilla, distal papilla, level of soft tissue margin, soft tissue contour, alveolar process, soft tissue color and soft tissue texture. The score is determined by comparison with a reference tooth (i.e. the corresponding tooth or a neighboring tooth). The score ranges from 2 to 0, with 2 being the best and 0 being the poorest score.

Consequently, the highest possible score is 14 and would represent the perfect match of the peri-implant soft tissue with that of the reference tooth.

Variables	0	1	2
Mesial Papilla	Absent	Incomplete	Complete
Distal Papilla	Absent	Incomplete	Complete
Level of soft tissue margin	Major discrepancy >2mm	Minor discrepancy < 2mm	No discrepancy
Soft tissue contour	Unnatural	Fairly natural	Natural
Alveolar process	Obvious deficiency	Slight deficiency	No deficiency
Soft tissue color	Obvious difference	Moderate difference	No difference
Soft tissue texture	Obvious difference	Moderate difference	No difference

In their study, 30 single implant-supported crowns were evaluated by 20 clinicians with different backgrounds (five prosthodontists, five oral surgeons, five orthodontists and five dental students). The assessment was completed twice at an interval of 4 weeks. The mean PES was 9.46 (3.81 SD) in the first assessment and 9.24 (3.8 SD) in the second assessment. In regards to the effect of specialization, orthodontists were found to have assigned statistically significantly poorer mean score (7.6) than any other group. Prosthodontists gave significantly higher mean ratings (10.6) than OMS. The mean total PES was 9.9 for dental students and 9.2 for OMS.

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The difference was not statistically significant. Lastly, when both assessments were compared, the analysis showed no statistically significant differences. Consequently, the PES proved to be a suitable instrument for reproducibly evaluating soft tissue around single implant-supported crowns. However, very low and very high ratings were associated with low standard deviations suggesting better reproducibility.
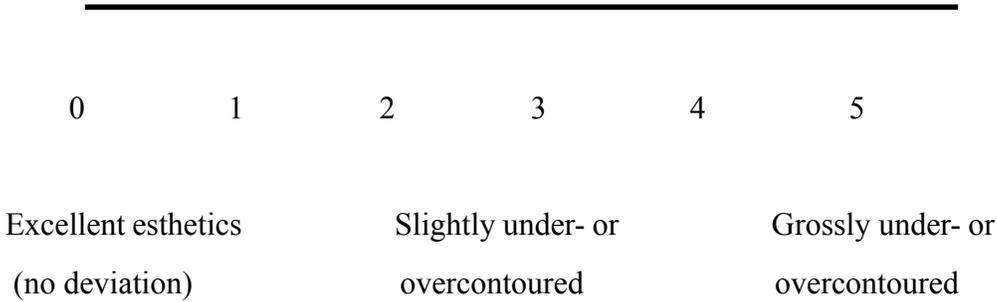
2) The Implant Crown Aesthetic Index[5]

Another evaluation was proposed by Meijer in 2005 to assess the esthetics of single implant-supported crowns. For this index nine different items were selected:

a) mesiodistal dimension of the crown: a five-point rating scale is applied to assess the harmony of the mesiodistal dimension of the crown with the adjacent and contralateral tooth

b) position of the incisal edge of the crown: a five-point rating scale is applied to assess the harmony of the position of the incisal edge with the adjacent and contralateral tooth

c) labial convexity of the crown: a five-point rating scale is applied to assess the harmony of the labial surface of the crown with the adjacent and contralateral tooth

d) color and translucency of the crown: a three-point rating scale is applied to assess the harmony of the color and translucency of the crown compared with the adjacent and contralateral tooth

e) surface of the crown: a three-point rating scale is applied to assess the harmony of the surface characteristics of the crown compared with the adjacent and contralateral tooth

f) position of the labial margin of the peri-implant mucosa: a maximum of three penalty points are applied depending on the position of the labial margin of the peri-implant mucosa which should be at the same level as the contralateral tooth and in harmony with the adjacent teeth (deviation of 1.5mm or more, less than 1.5mm of deviation or no deviation)

g) position of the labial mucosa in the approximal embrasures: a three-point rating scale is applied depending on the position of the interdental papillae (deviation of 1.5mm or more, less than 1.5mm of deviation and no deviation)
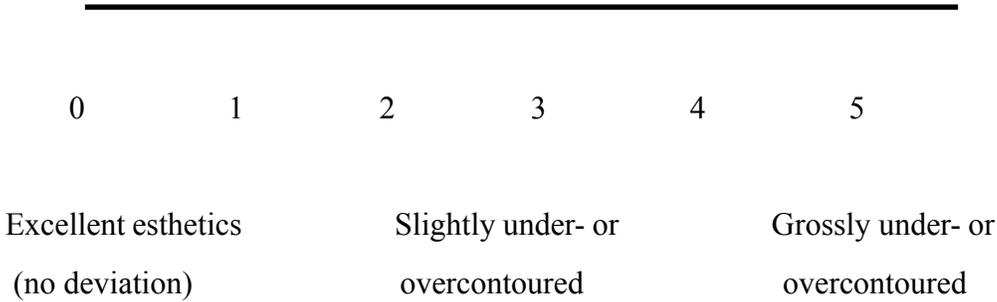
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h) contour of the labial surface of the mucosa: a five-point rating scale is applied to assess the harmony of the contour of the mucosa at the alveolar bone compared with the adjacent and contralateral tooth

i) color and surface of the labial mucosa: a three point rating scale is applied to assess the harmony and surface characteristics (presence of attached gingiva) when compared to the adjacent and contralateral tooth

The overall esthetic judgment of a single implant-supported crown is calculated by giving penalty points to each variable. One penalty point is applied for minor deviations while five penalty points are applied for major deviations. When the esthetic appearance is excellent no penalty points are given.

Mesiodistal dimension:

| 0 | 1 | 2 | 3 | 4 | 5 |

Excellent esthetics   Slightly under- or   Grossly under- or
(no deviation)   overcontoured   overcontoured

Position of the incisal edge:

| 0 | 1 | 2 | 3 | 4 | 5 |

Excellent esthetics   Slightly under- or   Grossly under- or
(no deviation)   overcontoured   overcontoured

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Labial convexity of the crown:

| 0 | 1 | 2 | 3 | 4 | 5 |

Excellent esthetics   Slightly under- or   Grossly under- or

(no deviation)   overcontoured   overcontoured

Contour of the labial surface:

| 0 | 1 | 2 | 3 | 4 | 5 |

Excellent esthetics   Slightly under- or   Grossly under- or

(no deviation)   overcontoured   overcontoured

Color and surface of the labial mucosa:

| 0 | 1 | 2 | 3 | 4 | 5 |

No mismatch   Slight mismatch   Gross mismatch

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Variables	0	1	2
Color and translucency of the crown	No mismatch	Slight mismatch	Gross mismatch
Surface of the crown	No mismatch	Slight mismatch	Gross mismatch
Position of the labial margin	No deviation	< 1.5mm of deviation	≥ 1.5mm of deviation
Contour of the labial surface	No deviation	< 1.5mm of deviation	≥ 1.5mm of deviation

Intra- and inter-observer agreement were tested by having two oral surgeons and two prosthodontists complete the index for 24 implant-supported single-tooth restorations twice within a 2-week period. In their study, the prosthodontists demonstrated better intra-observer agreement than the oral surgeons.

The reproducibility of both the PES and the ICAI as well as the influence exerted by the examiner's specialty background was investigated by Gerhke et al[6,7]. For the first study, standardized intraoral photographs of 30 patients with maxillary anterior implant-supported single crowns were evaluated by 15 clinicians (3 general dentists, 3 oral maxillofacial surgeons, 3 orthodontists, 3 postgraduate students in implant dentistry, and 3 lay people). The intra-observed agreement for all specialties was 70.5%. Orthodontists were found to assign significantly poorer ratings than any other group.

In regards to the reproducibility of the ICAI, Gherke et al. evaluated 23 implant-supported single crowns. Two general dentists, two orthodontists, and two dental technicians evaluated the crowns twice within a 4-week period. The intra-observer agreement for the ICAI was 67% between the two ratings. Orthodontists were, again, the specialist group which gave poorer mean scores to the evaluated crowns (3 and 2.93 in the first and second assessments respectively).

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3) The Pink Esthetic Score and the White Esthetic Score[8]

In 2009, The Journal of Periodontology published a new classification that included a slight modification of the Pink Esthetic Score (PES) proposed by Fürhauser and a new White Esthetic Score (WES).

The Pink Esthetic Score included the following five variables:

Variables	0	1	2
Mesial Papilla	Absent	Incomplete	Complete
Distal Papilla	Absent	Incomplete	Complete
Curvature of Facial Mucosa	Markedly different	Slightly different	Identical
Level of Facial Mucosa	>1mm discrepancy	< 1mm discrepancy	Identical vertical level
Root Convexity/Soft Tissue Color and Texture	Gross discrepancy of color and emergence profile	Slight discrepancy of color and emergence profile	Color and eminence match the contralateral tooth

Consequently, under optimum conditions, the total score of an implant-supported crown would add up to 10 points.

The White Esthetic Score focuses on the prosthetic part, the visible part of the restoration, and is based on the following parameters:

Variables	0	1	2
General Tooth Form	Gross Mismatch	Slight Mismatch	Identical
Outline and Volume of the Crown	Gross Mismatch	Slight Mismatch	Identical
Color	Gross Mismatch	Slight Mismatch	Identical

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Variables	0	1	2
Surface Texture	Gross Mismatch	Slight Mismatch	Identical
Translucency/ Characterization	Gross Mismatch	Slight Mismatch	Identical

Similar to the PES, the WES would add up to 10 points if the esthetic of the implant-supported restoration was excellent. Adding both the PES and the WES, the highest score is 20.

A retrospective cross-sectional study was completed to evaluate the esthetic outcome of 45 single implant-supported restorations completed from 2001 to 2004 at the University of Bern. The same protocol and type of implants were used for all the restorations that were evaluated.

The PES/WES analysis was completed twice (on different days) by one experienced prosthodontist who had not been involved in the fabrication of the restoration. A third evaluation was completed by a second prosthodontist. In case of disagreement, a short discussion was completed until consensus was reached.

One month after the follow-up examination, a questionnaire was sent to the 45 patients. Each question included a VAS (Visual Analogue Scale) to assess the degree of satisfaction. The first question addressed the overall treatment protocol including the therapy and length of treatment. The second question asked whether the treatment reached the patient's expectations. The final question addressed specifically the patient's satisfaction from an esthetic point of view. The mean total PES/WES was 14.7±1.18, being 7.8±0.88 for PES and 6.9±1.47 for WES. The investigators concluded that the PES/WES index demonstrated fulfilling important characteristics as a scoring system as well as reproducibility, ease of use and the definition of a threshold for clinical acceptability (<12 points).

Furthermore, they claimed both the protocol used for the implant placement (early implant placement) and the implants used demonstrated acceptable and predictable clinical results to replace single anterior maxillary teeth.

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4) The Complex Esthetic Index[9]

The last index published in the literature was proposed by Juodzbalys and Wang in 2010. They claimed no index included factors involving hard tissue and developed an index that assessed the underlying bone topography by means of a radiographic evaluation. The proposed index is composed of three components: the soft tissue index (S), predictive index (P), and the implant-supported restoration index (R). Each component consisted of five different variables to be rated as 20% if adequate, 10% if compromised and 0% if deficient. Consequently, each component can be rated up to 100% if the esthetic outcome is excellent.

Soft tissue index (S):

Variables	20%	10%	0%
Soft tissue contour	Identical to contralateral tooth	< 2mm difference	≥2 mm
Soft tissue vertical deficiency	Identical to contralateral tooth	1-2mm difference	≥2 mm
Soft tissue color and texture	Identical to contralateral tooth	Moderate variations	Obvious variations
Mesial papillae appearance	Complete fill	Partial fill	Absence
Distal papillae appearance	Complete fill	Partial fill	Absence

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Predictive Index (P):

Variables	20%	10%	0%
Mesial interproximal bone height	<5mm	5-7mm	>7mm
Distal interproximal bone height	<5mm	5-7mm	>7mm
Gingival tissue biotype	>2mm	1-2mm	<1mm
Implant apico-coronal position	1.5 to 3mm	3-5mm	>5mm
Horizontal contour deficiency	No deficiency	1-3mm	>3mm

Implant-supported restoration index (R):

Variables	20%	10%	0%
Color and translucency	No variation with contralateral tooth	Moderate variation	Obvious difference
Labial convexity in the abutment/implant junction	No variation with contralateral tooth	<1mm variation	Obvious difference
Implant/crown incisal edge position	No variation with contralateral tooth	± 1mm	± 2mm
Crown width/length ratio	<0.85	0.85-1	> 1
Surface roughness and ridges	No variation with contralateral tooth	Moderate variation	Obvious difference

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To determine the mesial and distal interproximal bone height, standardized periapical radiographs were exposed and the long-cone paralleling technique was used. The evaluation was completed measuring the distance from the cemento-enamel junction to the mesial and distal alveolar crest using a standardized computerized dental-imaging software. The implant apico-coronal position was recorded in a similar way.

The distance from the middle part of the implant to an imaginary line drawn to the buccal bone flange of the adjacent teeth was measured using a periodontal probe to determine the horizontal contour deficiency. Distances were defined as adequate if it was 0, compromised when the length was from 1 to 3mm and deficient if it was over 3mm.

The authors also provided a guideline to compare the scoring to the clinical results. When S, P, and R ratings were 100%, the esthetic results were excellent. Ratings from 60-90% corresponded with a compromised but clinically acceptable result. If the CEI was less than 50%, the clinical result is considered clinically unacceptable. If the esthetic result was excellent, the CEI was expressed as S100, P100, and R100.

For this study, 50 subjects previously treated with dental implants were evaluated for esthetic outcomes using the proposed CEI. The evaluations were completed by two calibrated oral surgeons twice during a two-week period. For the soft tissue evaluation, a high intra- and inter-observer agreement were observed and the mean score was 77.4 for examiner 1 and 78% (evaluation 1) and 78.4% (evaluation 2) for examiner 2. The intra- and inter-observer agreement for P evaluation were also good. The mean P was 67.4% and 66.6% evaluated by examiner 1 and 67.6% and 67.4% recorded by examiner 2 for evaluations I and II, respectively. A very good intra- and inter-observer agreement was observed for the R evaluation. The mean R was almost identical for both examiners and ranged from 82.8% to 83.6%. The investigators concluded their assessment was a reproducible tool for determining the predictability of anterior implant esthetics.

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The only publication found in the literature comparing   the assessment of single implant-supported restorations from the esthetic point of view was published by Vilhjálmsson in 2011[10]. Fifty patients with agenesia or loss of teeth in the anterior maxillary region due to traumatic dental injury (TDI) were selected to participate in the study. 56 single implant-supported crowns were evaluated using the PES described by Meijer, the Californian Dental Association Classification (CDA), the ICAI and a modified version of the ICAI. For this study, the three variables used in the CDA to rate the prosthetic outcome were transferred into points ranging from 0 to 3. The R-level represented no mismatch with the contralateral or adjacent tooth and it was scored as 0; the S-level (slight mismatch)=1; the T-level (mismatch)=2 and V-level (gross mismatch)=3. Consequently, a total of 9 penalty points could be given for the CDA.

Moreover, the ICAI rates from 0 to 5 penalty points for some of its variables. However, for this study, a modification of the index was used in which gross deficiencies are scored with a maximum of 2 penalty points. Therefore, the maximum total score per crown would sum up to 18 points. For both the ICAI and the mod-ICAI, a crown score and a mucosa score were calculated independently.

All of the participants in the study, were given a questionnaire including questions about their satisfaction with both the prosthetic part of the implant and the surrounding soft tissue. For all indices, a good to excellent inter and intra-examiner agreement was observed. A total of 84% and 88% of the participants were satisfied or very satisfied with the form and color of their new crowns. Seventy two percent of the participants were satisfied or very satisfied with the form and color of the adjacent mucosa.

As for the correlations of the indices with the answers related to aesthetics from the participants, the responses about the form of the new crown did not correlate with any of the indices. The most significant correlation was observed for the mod-ICAI (0.30-0.38, p<0.05). Lastly, a strong correlation was found between PES, ICAI and mod-ICAI (0.73 and 0.74, respectively). However, a low correlation was observed between PES and CDA (0.37).

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It is worth mentioning that the study was completed with participants who had agenesia or TDI. Therefore, the esthetic results may not be comparable with other indications for implant therapy such as periodontal pathology.

The study concluded the CDA demonstrated poor correlation with both other indices and the patient's perception as it was not designed for scoring implant-supported crowns. The modified ICAI was the index that best correlated with other indices and the patient's perception of the esthetics of anterior maxillary implant-supported crowns.

A recent systematic review evaluated the extent to which esthetic analyses are included among the success criteria for evaluation of implant-supported restorations, as well as, the use in clinical trials of different esthetic indices[11]. The authors concluded that there are no universally accepted evaluation criteria of the esthetic outcome of implant-supported restorations. The most frequently used index observed by the authors was the Papilla Index. This index was described by Jemt in 1997[12] and it measures the presence and height of papillae adjacent to dental implants. Although this index has demonstrated clinical value and ease of use, it provides partial judgment of the esthetic result as only one variable involved in the overall esthetic outcome is considered.

To the best of our knowledge, no previous study has determined the specificity and sensitivity of the purposed indices. Furthermore, no comparison has been published of the inter- and intra-examiner evaluation of the three most widely used indices: the PES/WES, the modified ICAI and the CEI. This fact leads to the undesired lack of uniformity of the evaluation of the esthetic outcomes currently available in the scientific implant literature.

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Specific aims and hypothesis

The purpose of this study is to determine which of the indices, PES/WES, modified ICAI or CEI, best correlates with the patient's assessment of the esthetic appearance of implant-supported crowns in the anterior maxilla.

The only study published with a comparison of previously reported esthetic indices (CDA, PES, ICAI and modified ICAI)[10], demonstrated that the modified ICAI had a better reproducibility and a higher correlation with the patient's assessment than the other indices. However, PES and CDA only included the soft tissue evaluation. In our study, both the soft tissue and the prosthetic part of the implant restoration are considered and evaluated in each of the indices. Consequently, it is less clear which of the indices will demonstrate superiority. Our null hypothesis is that there are no differences between the sensitivity and specificity of the three indices. Our alternative hypothesis is that the modified ICAI demonstrates a better correlation with the patient's assessment.

The intra- and inter-examiner agreement will be calculated to determine the reproducibility of each index. It is hypothesized, that for our study a significant difference will be observed between orthodontists and all other specialty groups.

The influence of the parameters that concern the soft tissue index will be compared to that of the parameters concerning the restorative part of the crown. With this evaluation, we aim to determine which variables are of greater importance for the patient's overall satisfaction with the esthetics of their implant-supported crowns.

Lastly, the Tufts University School of Dental Medicine (TUSDM) esthetic implant score will be determined. The mean esthetic score obtained for each one of the implants evaluated in the study will be determined and compared to previously reported scores in the literature. Due to the small sample size, the esthetic score may not be representative of all the single-implant supported crowns completed at TUSDM. Nevertheless, it will be calculated for comparative

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reasons.

It is our ultimate goal, that this study will set the stage for a future unique and comprehensive esthetic analysis of single implant-supported crowns that can be standardized and easily used by practitioners of all specialties.

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Research Design and Methods

The patient database of Tufts University School of Dental Medicine (TUSDM) was accessed and a search was completed to find patients that had undergone implant therapy in the maxillary anterior sextant at TUSDM.

Inclusion Criteria:

    1) Patients over 18 years old

    2) Single maxillary anterior implant-supported crowns completed at TUSDM

    3) Implant crown in function for over one year

Exclusion Criteria:

    1) Medically compromised patients

    2) Women who were pregnant

The sample size was calculated to determine both the number of patients that needed to be recruited for the study as well as the number of clinicians from different specialties that would evaluate the implant esthetic scores. Based on the literature, we anticipated that the sensitivities of the indices range from 0.60 to 0.80. Thus, with 25 subjects, we would have 98% power to detect this difference, assuming an alpha of 0.05 (using nQuery advisor, 7.0). For the comparison of intra- and inter-examiner agreement between different specialties it was assumed that among specialties a higher agreement would be reached. According to previous studies, kappa values should range between 0.62 and 0.78. Thus, with 5 evaluators per specialty, each applying 4 indices to 4 distinct cases, we would have an 84% power to detect this difference, assuming an alpha of 0.05 (using nQuery Advisor, 7.0).

Patients who fulfilled the aforementioned criteria were contacted and informed of the study. Patients were reached until 25 subjects agreed to participate. An appointment was then scheduled at their best convenience.

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During the appointment, the study was explained to the subjects and they were asked to sign the Informed Consent form if they agreed to participate.

The participants were asked to answer a detailed questionnaire assessing their satisfaction with the overall treatment and the esthetic result of the implant-supported crowns. The questionnaire was designed by the master's candidate and reviewed by the thesis committee. Before initiating the study, the questionnaire was validated. The Tufts University Health Sciences Campus Institutional Review Board (IRB) at TUSDM approved the questionnaire validation portion of the study, as well as the main study. The questionnaire validation consisted of assessing the ease of use and simplicity of the questionnaire among ten residents (5 from the Department of Periodontology and 5 from the Department of Prosthodontics and Operative Dentistry) at TUSDM as well as ten patients. A copy of the questionnaire is attached to this document. The questionnaire was designed to address each of the variables included in the indices independently. Each question was asked to be answered with "yes" or "no", as well as with a numeric code ranging from one to five to assess the degree of satisfaction. An oral exam was then completed for oral cancer screening purposes.

Photographs were taken using the same digital camera with identical settings for each image, to avoid possible bias. The following photographs were obtained from each subject:
- A frontal image of teeth #6 to #11 using a black background for contrast
- A close-up image of the crown including both adjacent teeth using a black background for contrast

A standardized periapical radiograph was exposed using the long-cone paralleling technique. The same type sensor (Shick® Sensor CDR size #1) as well as positioning device (XCP Dentsply® Radiographic Rinns) were used for standardizing purposes. The periapical radiograph was only obtained if the latest radiograph of the implant was older than one year. Finally, the participants were given a $25 Amazon® gift card in appreciation for their enrollment and participation.

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The aforementioned evaluation, photographs and radiographic examination was completed by the same investigator. The three indices were completed for each patient by an independent examiner.

All the subjects were screened and evaluated during the months of April and May of 2013.

The information collected was added to an electronic database for evaluation by the specialists. The database included the photographs and periapical radiograph taken during the appointment.

In order to assess the intra- and inter-observer agreement, five oral surgeons, five prosthodontists, five periodontists and five orthodontists were contacted to answer a questionnaire that included the three indices evaluated in the study. All specialists were asked to attend a meeting where four representative cases out of the 25 cases were selected and presented with the clinical images and radiographs. For ease of recruitment, clinicians contacted were faculty at TUSDM. None of the specialists in the thesis committee participated to avoid any possible bias. No compensation, except for a free lunch, was offered to specialists participating in the study, nonetheless, lunch was provided to all of them. Two weeks after the first evaluation was completed, the clinicians were asked to answer the questionnaire for a second time with a different order. This part of the study was completed during the month of May of 2013.

All the information collected in the questionnaires was then introduced into an online database for statistical analysis. The statistical analysis was performed using the software packages SPSS Version 19.0 and SAS Version 9.2.

Primary outcomes evaluated were the sensitivity and specificity of each index as well as the area under the receiver-operator characteristic (ROC) curve. The secondary outcome included the evaluation of the intra- and inter-examiner agreement. For this purpose, a Pearson's correlation was performed. Independent sample t-tests were run to determine the importance the patient's gave to the parameters considered in every index. The questions about soft tissue and those related to the restorative portion were compared to the overall patient's assessment or satisfaction with the implant-supported crown. The mean of all four cases evaluated by the

representative of all single implant-supported crowns placed at TUSDM, assessing the overall esthetic score would be useful to compare it with other results reported in the literature.

Results

Twenty five subjects (14 females and 11 males) were recruited for the present study. The mean (SD) age of the participants was 49.04±14 with patients ranging from 25 to 69 years old. Of the patients evaluated, 19 (76%) were Caucasian, 4 patients were African-American (16%), one was Asian (4%) and one patient did not report his race/ethnic group (4%). As far as the distribution of the implants evaluated is concerned, out of the twenty five crowns there were two right canines (8%), four right lateral incisors (16%), six right central incisors (24%), seven left central incisors (28%), four left lateral incisors (16%) and two left canines (8%).

To assess the specificity and sensitivity, the Area Under the Curve (AUC) was calculated for each one of the indices. The AUC for the PES/WES was 0.53, for the modified ICAI was 0.7 and for the CEI 0.56. (See Figures 1, 2 and 3)

For each esthetic index, the best sensitivity and specificity were calculated using the Youden Index. These were 100% specificity and 36% sensitivity for the CEI for a cut point of 0.2, a 100% specificity and 0% sensitivity for the modified ICAI for a cut point of 0.2, and 66% specificity and 95% sensitivity for the PES/WES for a cut point of 0.75.

The intra-observer agreement was assessed using the Pearson's correlation. The calculated correlations between the first and second evaluations were 0.737 ($p < 0.001$) for the PES/WES, 0.647 ($p < 0.001$) for the modified ICAI and 0.614 ($p < 0.001$) for the CEI. Consequently, there was good agreement between the first and second evaluation of the participants for all of the indices evaluated. (See Figure 4, 5 and 6)

There were no differences observed between specialists in any of the indices evaluated. For the PES/WES, the highest score was given by an orthodontist (10/20) and the lowest by an oral maxillofacial surgeon (0/20). The highest mean was given by prosthodontists but there were no statistically significant differences between specialists (p=0.515 and 0.538 for the first and second assessment, respectively).

For the modified ICAI, the highest score, which would represent the poorest esthetic result, was given by an oral maxillofacial surgeon (18/18) and the lowest score was given by a periodontist (0/18). The highest mean was given by oral maxillofacial surgeons but there were no statisitcally significant differences between groups ($p=0.531$ and $p=0.424$ for the first and second assessment, respectively).

As far as the CEI is concerned, the highest scored was given by orthodontists and prosthodontist (300/300) and the lowest score was given by oral maxillofacial surgeons (70/300). The highest mean was obtained by prosthodontists (201.50/300) but there were no statistically significant differences between groups ($p=0.919$ and $p=0.666$, respectively, for the first and second evaluation).

To assess the influence of the independent parameters on the overall patients' satisfaction, an independent sample t-test was performed. For PES/WES, the presence of the mesial papillae was the only variable that was significantly different between satisfied and unsatisfied patients. As for the modified ICAI, the mesiodistal dimension of the crown, the position of the incisal edge and the contour of the labial surface of the mucosa were significantly different between satisfied and unsatisfied patients. Last but not least, the parameters that demonstrated significant differences depending on the satisfaction of the patient were mesial papillae, mesial interproximal bone height, distal interproximal bone height, implant apico-coronal position and crown incisal edge position.

The patient's questionnaire was designed so that every question would relate to a parameter in each index. The purpose of this was to assess if there was any difference in the distribution of scoring by the professional if the patient was satisfied or not with each given parameter.

With PES/WES, the color of the crown had a different scoring distribution if patient's were satisfied with it compared with patients who were not satisfied ($p=0.009$). However, no other parameter seemed to be correlated with the patient's opinion or observation. As for the ICAI and

the CEI, no parameter proved to be correlated with the patient's perception or satisfaction. (See tables 4, 5, and 6)

Furthermore, for PES/WES there were no significant differences between the means for patients that were satisfied and unsatisfied (p=0.810). The mean was 11.64 for satisfied patients and 10.33 for unsatisfied patients. Also, there was no difference in the total ICAI mean for patient's who were satisfied and patients who were unsatisfied (p=0.837). The mean was 6.41 for satisfied patients and 8.67 for unsatisfied patients. Lastly, the overall CEI mean for satisfied patients was 207.27 and for the unsatisfied 200. There was no statistically significant difference between satisfied and unsatisfied patients (p =0.52).

The overall mean for the implant-supported crowns completed at TUSDM were 11.48 for the PES/WES, 6.68 for the modified ICAI and 206.4 (S=62.4%, P=81.2% and R=62.8%) with CEI. A collage with all the images from the subjects was added for comparison. (See Figure 7)

Discussion

This study is the first one to compare the specificity and sensitivity of the PES/WES, ICAI, modified-ICAI, and CEI. These indices were published between 2005 and 2010 to evaluate the esthetic outcome of implant-supported crowns in the anterior maxillary area.

In our study, the modified ICAI demonstrated a greater specificity as shown by the Area Under the Curve. In the study published by Vihljáhmsson[10] comparing the CDA, PES, ICAI, and the modified-ICAI, the last one demonstrated greater correlation with the patient's perception. The CDA index[13] was developed to evaluate the esthetics of single conventional crowns and includes parameters that are not correlated with implant-supported crowns, such as caries development in the crown margin. In addition, The PES is limited to the soft tissue profile and consequently gives incomplete information. When ICAI and the modified-ICAI are taken into consideration, it should be mentioned that the sole difference between them is the scoring assignment. Whereas in the ICAI some of the variables can be scored from 0 to 5 penalty points, the modified-ICAI gives a maximum of two penalty points. Narrowing the scoring range has been shown to be easier to use for both patients and clinicians and therefore, was proven a better correlation with the patients' assessment as well as greater reproducibility.

For our study, two other indices have been chosen for evaluation. All indices included the evaluation of both soft tissues and restoration. Furthermore, the CEI included a radiographic assessment of the crown. The highest correlation observed was for PES/WES and all indices evaluated demonstrated a strong agreement without statistically significant differences between the first and second evaluation among the specialists. While the differences were not significant, there was a general agreement among clinicians that the PES/WES was more user-friendly.

The intra-observer agreement has been previously investigated by numerous researchers. Gherke et al.[6] reported an overall agreement for all occupational groups of 70.5% when the PES was evaluated. Meijer[5] reported an intra-observer agreement that ranged between 67.1% and 86.6%

when the ICAI was applied to 24 implant-supported crowns. Similarly, the ICAI intra-observer agreement published by Gherke was 67%[7]. For the CEI, their creators found an agreement that ranged between 84% to 94%[9]. Moreover, depending on the index used, Vhiljhámson et al[10] found an intra-observer agreement that ranged between 62% to 68%. The results of our study could not be correlated with previous studies as different statistical analyses were used. Cohen's Kappa test could not be applied as it takes into account categorical variables instead of continuous measures.

When the degree of specialization was taken into account, previous studies reported that lower scores were given by orthodontists. A possible explanation for this phenomenon would be that orthodontist are rarely involved in the rehabilitation of single missing teeth. Their possible role in implant therapy would involve creating the adequate space for the future implant and restoration but there are not involved in the surgical placement of the implant or the fabrication of the implant-supported crown, in any case. Consequently, these specialists could be less aware of the challenges esthetic single implant-supported restorations pose, and could, therefore, be more demanding than periodontists, prosthodontists and oral surgeons. However, in our study, there were no significant differences recorded between specialists. All specialists were teachers at TUSDM. There was a wide range in years of experience, and none of the specialists were familiar with the indices evaluated. These factors ensured some equivalence between the different specialists.

Overall, patients' assessment of the esthetic appearance of a tooth is expected to be higher than those made by the clinicians, regardless of the degree of specialization. In fact, despite the range of scoring obtained by the clinicians, only three of the twenty five participants reported to be unsatisfied with the esthetic result of their implant-supported crowns.

Kokich et al[14] evaluated the esthetic perception of minor changes in the tooth shape, alignment and soft tissue in the anterior maxillary sextant. Intentionally altered photographs were evaluated by orthodontists, general dentists and lay people. Overall, orthodontists seemed to be more sensitive to minor changes, while general dentists and lay people were more forgiving with

minor changes. Consequently, the range of subjective impressions of the beholder is well known and depends on the degree of specialization. Chang et al[15] demonstrated a high level of satisfaction with the treatment outcome among patients. However, their opinion did not correlate with the assessment of these cases by prosthodontists, who assigned a much lower rating to their treatment outcome. The author interpreted these results to the effect that either clinicians are more critical or the patients apply different standards to evaluate the outcome.

To the extent of our knowledge, no previous study has observed the influence of different categorical variables to the overall patient's esthetic satisfaction of their implant-supported crown. Different parameters demonstrated to be significantly different depending on the patient's satisfaction. Consequently, these parameters are considered to influence more the patient's perception of beauty. For PES/WES and CEI the presence of the mesial papillae was significantly different in satisfied patients. Moreover, in both the modified ICAI and CEI, the position of the incisal edge was observed as an influential parameter. It can be concluded that both soft tissue and hard tissue parameters are of importance when evaluating the esthetic result of single implant-supported crowns and that harmony is considered in a wide framework, in this case, the patient's smile.

The mean PES score reported by Fürhauser[4] ranged between 9.24 to 9.46. Belser[8], reported a mean PES/WES of 14, obtaining an independent PES score of 7.8 and a WES score of 6.9. In our study, the mean for the PES/WES was 11.48, with an independent PES mean score of 6 and WES score of 5.48. The fact the mean scores were slightly lower in our study, could be explained on the basis that the implants evaluated in Belser's study were completed by two experienced surgeons and all the crowns were completed by experienced dentists in Switzerland. At TUSDM, the implants were placed and restored by residents and dental students. It is expected, that their experience and clinical skills were substantially lower than the Switzerland's dentists.

The median scores reported by Vilhjálmsson et al[10] are 8, 9 and 6, for the PES, the ICAI, and the modified-ICAI, respectively. Unfortunately, they did not report the mean of the crowns that were evaluated with neither of the indices. However, it is important to take into consideration that their

implants were placed in patients with agenesia or trauma, which would make the populations difficult to compare.

Juodzbalys and Wang[9] reported a mean Soft Tissue Index of 78%, a mean Predictive Index of 67.4% and a mean Restorative Index of 82.8%. Our results found means of 62.4%, 81.2% and 62.8% for the Soft Tissue Index, the Predictive Index and the Restorative Index, respectively. Clinical guidance was provided by the authors suggesting that a 100% is an excellent esthetic result, between 60% and 90% a compromised result and less than 60% a deficient esthetic result. The investigators results as well as the results of the present study would be considered compromised as far as esthetics is concerned.

Limitations:

It is of importance to mention that the small sample size may have influenced the fact that no differences were observed between indices. It would be desirable to assess these indices in a wider population range and to have the clinicians complete the evaluations on the patients instead of using clinical pictures. Also, the fact that only three of the patients reported to be unsatisfied decreased the power of the sensitivity and specificity analysis. Ideally, we would have liked to consider a sample of patients with a more evenly distributed perception of the esthetics of the implant-supported crowns.

Initially, we aimed to consider patients that had a single implant-supported crown without adjacent or contralateral restored teeth (e.g. crowns, veneers). Unfortunately, the pool of patients with these characteristics was not large enough. It was decided subsequently and in agreement with with the statistician and the rest of the members of the thesis committee, to eliminate this exclusion criterion. On the basis of the fact that patients evaluate the harmony of their whole smile regardless of the presence or absence of any restoration. This change permitted the access to a greater pool of patients and the clinical evaluation could be completed within the time previously discussed.

Conclusions

Within the limitations of the present study, it can be concluded that the modified ICAI demonstrated a higher specificity, although the results were not statistically significant. The PES/ WES, modified ICAI and CEI demonstrate a good intra-observer agreement. Furthermore, no differences were observed between orthodontists, periodontists, prosthodontists and oral surgeons when all three indices were applied for different cases. Both soft tissue and restorative parameters seemed to influence the patient's esthetic perception. Further research is needed to assess if any of the present indices demonstrates a greater correlation with patient's perception as well as intra- and inter-observer agreement to warrant a universal and standardized clinical use.

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Esthetic Evaluation Form
Patient's Section

On behalf of the research team, we would like to thank you for participating in this survey.

Please, fill in the following questions:

Overall, are you satisfied with how the implant-supported crown looks?

Yes	No

How satisfied are you?

1	2	3	4	5
Very Disatisfied	Not Satisfied	Neutral	Satisfied	Very Satisfied

1) Is there any gap/space between the crown and the tooth to the right?

Yes	No

If your answer is yes, rate your agreement with the following statement:
"The gap negatively affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2) Is there any gap/space between the crown and the tooth to the left?

Yes	No

If your answer is yes, rate your agreement with the following statement:
"The gap negatively affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3) Is the gum over the crown at the same level as the gum over the neighboring teeth?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the gum level affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4) Does the shape of the gum over the crown resemble the shape of the gum of the neighboring teeth?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the shape of the gum affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

5) Is the color of the gum over the crown similar to the color of the gum over the neighboring teeth?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the color of the gum affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

6) Is the texture of the gum over the crown similar to the texture of the gum over the neighboring teeth?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the texture of the gum affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

7) Do the crown and the same tooth on the opposite side have the same width?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the width of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

8) Do the crown and the same tooth in the opposite side have the same length?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the length of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

9) Do the crown and the same tooth on the opposite side have a similar bulkiness?

Yes	No

If your answer is no, rate your agreement with the following statement:
"The difference in the bulkiness of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

10) Is the overall shape of the crown similar to the same tooth on the opposite side?

Yes	No

    If your answer is no, rate your agreement with the following statement:
    "The difference in the shape of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

11) Do the crown and the neighboring teeth have a similar color?

Yes	No

    If your answer is no, rate your agreement with the following statement:
    "The difference in the color of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

12) Do the crown and the neighboring teeth have a similar texture?

Yes	No

    If your answer is no, rate your agreement with the following statement:
    "The difference in the texture of the crown affects the esthetic appearance of the crown."

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

!

Overall, are you satisfied with how the implant-supported crown looks?

Yes	No

How satisfied are you?

1	2	3	4	5
Very Disatisfied	Not Satisfied	Neutral	Satisfied	Very Satisfied

On behalf of the research team, we would like to thank you for participating in this survey.

!

Esthetic Evaluation Form
Specialist's Section

Name:_____   Subject ID:___

!

Esthetic Evaluation Form   Subject ID:_____
Specialist's Section

Evaluation of the sensitivity and specificity of three indices to assess the esthetic result of single implant-supported crowns.

Master's candidate: Berta Garcia Mur, DMD
Principal Investigator: Hans-Peter Weber, DMD, MS, PhD

Please indicate the following information:

    Your specialty:_____

    The patient's reference number:_____

On behalf of the Research Committee, we would like to thank you for participating in this study. All the information provided will be used to compare the following indices described in the literature for the evaluation of the esthetic of single implant-supported crowns in the anterior maxilla.

Please fill in the following indices.

1) PES/WES

Variables	0	1	2
Mesial Papilla	Absence	Incomplete presence	Complete presence
Distal Papilla	Absence	Incomplete	Complete
Curvature of Facial Mucosa	Markedly different	Slightly different	Identical
Level of Facial Mucosa	Major (≥ 1mm) discrepancy	Slight (≤ 1mm) discrepancy	Identical vertical level
Presence, partial presence or absence of convex profile/Mucosal Color/Surface Texture	None or only one parameter matches the contralateral tooth	Two criteria are fulfilled	All three parameters are more or less identical to the contralateral tooth

Variables	0	1	2
General Tooth Form	Major discrepancy	Minor discrepancy	No discrepancy
Outline and Volume of the Clinical Crown	Major discrepancy	Minor discrepancy	No discrepancy
Color (hue/value)	Major discrepancy	Minor discrepancy	No discrepancy
Surface Texture	Major discrepancy	Minor discrepancy	No discrepancy
Translucency/ Characterization	Major discrepancy	Minor discrepancy	No discrepancy

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2) The Modified Implant Crown Aesthetic Index

Variables	0	1	2
Mesiodistal dimension of the crown	No deviation	Slightly under- or overcontoured	Grossly under- or overcontoured
Position of the incisal edge of the crown	No deviation	Slightly under- or over contoured	Grossly under- or overcontoured
Labial convexity of the crown	No deviation	Slightly under- or over contoured	Grossly under- or overcontoured
Contour of the labial surface of the mucosa	No deviation	Slightly under- or over contoured	Grossly under- or overcontoured
Color and surface of the labial mucosa	No mismatch	Slight mismatch	Gross mismatch
Color and translucency of the crown	No mismatch	Slight mismatch	Gross mismatch
Surface of the crown	No mismatch	Slight mismatch	Gross mismatch
Position of the labial margin of the peri-implant mucosa	No deviation	< 1.5mm of deviation	≥ 1.5mm of deviation
Position of mucosa in the approximal embrasures	No deviation	< 1.5mm of deviation	≥ 1.5mm of deviation

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3) Complex Esthetic Index:

Soft tissue index (S):

Variables	Adequate 20%	Compromised 10%	Deficient 0%
Soft tissue contour variations	No	< 2mm difference	≥2 mm
Soft tissue vertical deficiency	No	1-2mm difference	≥2 mm
Soft tissue color and texture variations	No	Moderate	Obvious
Mesial papillae appearance	Complete fill	Partial fill	None
Distal papillae appearance	Complete fill	Partial fill	None

Predictive index (S):

Variables	Adequate 20%	Compromised 10%	Deficient 0%
Mesial interproximal bone height	<5mm	5-7mm	>7mm
Distal interproximal bone height	<5mm	5-7mm	>7mm
Gingival tissue biotype	>2mm	1-2mm	<1mm
Implant apico-coronal position	1.5 to 3mm	>3-5mm	>5mm
Horizontal contour deficiency	No	1-3mm	>3mm

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Complex Esthetic Index cont.:

Implant-supported restoration index (R):

Variables	Adequate 20%	Compromised 10%	Deficient 0%
Color and translucency	No	Moderate	Obvious
Labial convexity in the abutment/implant junction	No	<1mm	<2mm
Implant/crown incisal edge position	No	± 1mm	±2mm
Crown width/length ratio	<0.85	0.85-1.0	>1.0
Surface roughness and ridges	No	Moderate	Obvious

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Tables and figures

Figure 1: Representation of the AUC for the PES/WES

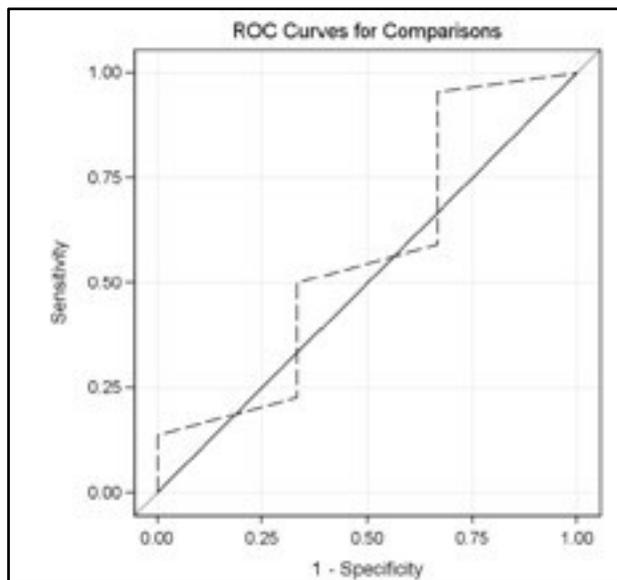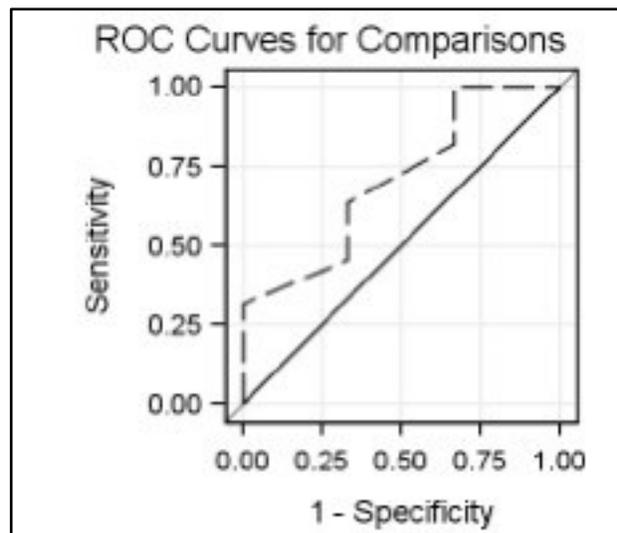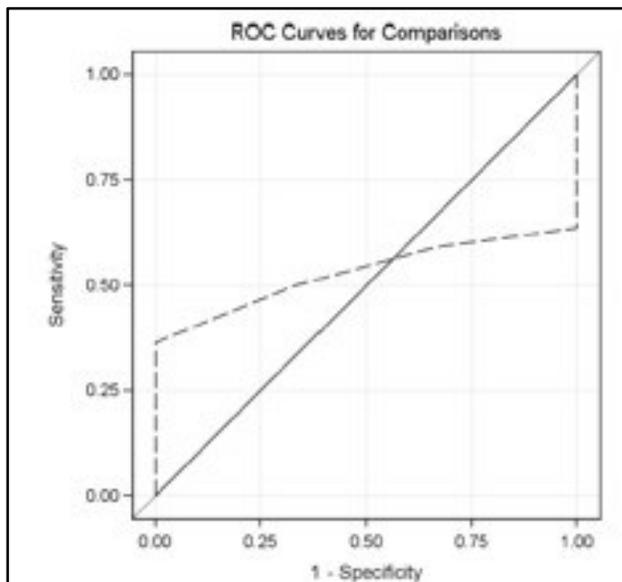Figure 2: Representation of the AUC for the CEI

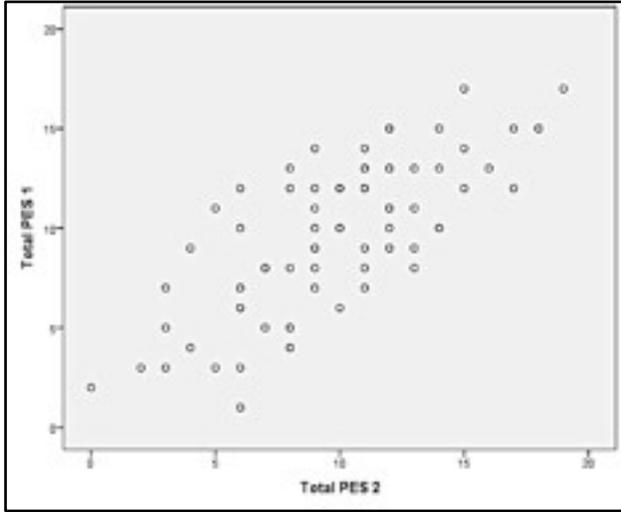Figure 3: Representation of the AUC for the modified ICAI

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Figure 4: Representation of the correlation of the first and second assessment of PES/WES

Figure 5: Representation of the correlation of the first and second assessment of modified ICAI
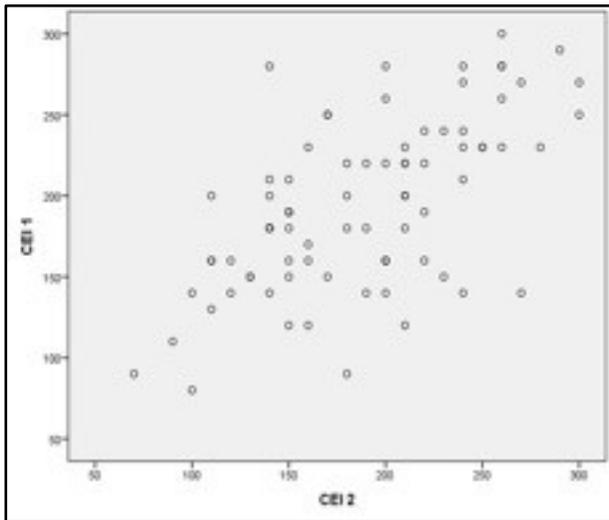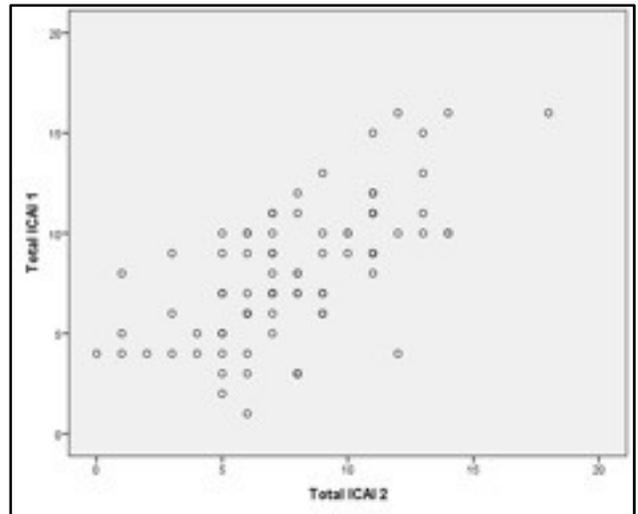
Figure 6: Representation of the correlation of the first and second assessment of the CEI

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	1st Evaluation				2nd Evaluation			
	Mean	SD	Max	Min	Mean	SD	Max	Min
Orthodontists	10.25	3.81	17	3	9.3	4.305	19	3
Periodontists	8.85	3.911	15	4	9.6	3.331	18	3
Prosthodontists	10.55	2.964	15	3	11	3.372	17	4
OMFS	9.75	4.351	15	1	9.8	4.467	18	0

Table 1: Mean, SD, maximum and minimum values from different specialists on the first and second evaluation for the PES/WES

	1st Evaluation				2nd Evaluation			
	Mean	SD	Max	Min	Mean	SD	Max	Min
Orthodontists	192	49.054	300	110	182	56.531	280	90
Periodontists	190.50	52.563	280	90	182.50	48.653	270	100
Prosthodontist	201.50	53.830	280	80	201	56.559	300	100
OMFS	194.63	57.718	290	90	188.50	55.939	290	70

Table 2: Mean, SD, maximum and minimum values from different specialists on the first and second evaluation for the modified ICAI

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	1st Evaluation				2nd Evaluation			
	Mean	SD	Max	Min	Mean	SD	Max	Min
Orthodontists	7.35	3.617	15	3	7.90	3.339	13	1
Periodontists	8.30	3.658	15	1	8.80	3.592	14	0
Prosthodontist	7.70	3.011	16	3	7	3.224	14	1
OMFS	8.85	3.438	16	4	7.65	3.689	18	1

Table 3: Mean, SD, maximum and minimum values from different specialists on the first and second evaluation for the CEI

Parameter	Percent		p-value
	Yes	No	
Mesial Papillae			0.96
0	10	0	
1	80	53.3	
2	10	46.7	
Distal Papillae			0.72
0	0	5.3	
1	100	47.4	
2	0	47.4	

!

Parameter	Percent		p-value
Curvature of facial mucosa			0.205
0	18.8	11.1	
1	75	55.6	
2	6.3	33.3	
Level of facial mucosa			0.27
0	0	40	
1	40	20	
2	60	40	
Root convexity/Soft Tissue Color and Texture			0.791
0	20	10	
1	60	70	
2	20	20	
General tooth form			0.373
0	5.3	16.7	
1	78.9	50	
2	15.8	72	
Outline and volume of the crown			0.417
0	17.6	37.5	
1	76.5	50	
2	5.9	12.5	
Color of the crown			0.009
0	12.5	66.7	

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Parameter	Percent		p-value
1	43.8	33.3	
2	43.8	0	
Surface texture			0.404
0	0	0	
1	52.4	75	
2	47.6	25	

Table 4: Distribution of scoring for each parameter in the PES/WES and p value.

Parameter	Percent		P value
Mesiodistal dimension			0.771
0	45	60	
1	50	40	
2	5	0	
Position of the incisal edge			0.211
0	85	60	
1	15	40	
2	0	0	
Labial convexity of the crown			0.185
0	26.3	16.7	
1	73.6	66.7	
2	0	16.7	

!

Parameter	Percent		P value
Contour of the labial surface			0.211
0	12.5	33.3	
1	87.5	66.7	
2	0	0	
Color and surface of the labial mucosa			0.261
0	6.7	10	
1	86.7	60	
2	6.7	30	
Color and translucency of the crown			0.125
0	31.3	0	
1	56.3	66.7	
2	12.5	33.3	
Surface of the crown			0.59
0	47.6	25	
1	52.4	50	
2	0	25	
Position of the labial margin			0.116
0	53.3	40	
1	40	20	
2	6.7	40	
Position of the mucosa in the approximal embrasures			0.155
0	20	13.3	

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Parameter	Percent		P value
1	60	86.7	
2	20	0	

Table 5: Distribution of scoring for each parameter in the ICAI and p value.

Parameters	Percent		P value
	Yes	No	
Soft tissue contour			0.683
0%	12.5	11.1	
10%	62.5	77.8	
20%	25	11.1	
Soft tissue vertical deficiency			0.432
0%	0	10	
10%	26	30	
20%	73	60	
Soft tissue color and texture			0.452
0%	6.7	20	
10%	86.7	80	
20%	6.7	0	
Mesial Papillae appearance			0.96
0%	10	0	
10%	80	53.3	
20%	10	46.7	

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Parameters	Percent		P value
Distal Papillae appearance			0.72
0%	0	5.3	
10%	100	47.4	
20%	0	47.4	
Color and translucency of crown			0.86
0%	12.5	33.3	
10%	50	66.7	
20%	37.5	0	
Labial convexity in the abutment/implant juction			0.838
0%	25	22.2	
10%	43.8	55.6	
20%	31.3	22.2	
Implant/crown incisal edge position			0.211
0%	0	0	
10%	15	40	
20%	85	60	
Crown width/length ratio			0.482
0%	20	0	
10%	55	80	
20%	25	20	
Surface roughness and ridges			0.577
0%	9.5	25	

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Parameters	Percent		P value
10%	42.9	50	
20%	47.6	25	

Table 6: Distribution of scoring for each parameter in the CEI and p value.

Figure 7: Collage of the images from the 25 crowns evaluated.
The last three images correspond to the dissatisfied patients

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